NEW HAMPSHIRE FLOOD PLAIN MANAGEMENT SERVICES

OLIVERIAN DAM
DAM-BREACH FLOOD ANALYSIS
TOWNS OF BENTON AND HAVERHILL, NEW HAMPSHIRE

APRIL 2000

US Army Corps
of Engineers

New England District

OLIVERIAN DAM
DAM-BREACH
FLOOD ANALYSIS

Town of Benton, New Hampshire
and
Town of Haverhill, New Hampshire

PREPARED FOR:

State of New Hampshire
Department of Environmental Services
Water Division

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Concord, Massachusetts

April 2000

Oliverian Dam

Dam-Breach Flood Analysis

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Oliverian Dam

Dam-Breach Flood Analysis

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Oliverian Dam

Dam-Breach Flood Analysis

1. PURPOSE

This report presents the findings of a dam-breach flood analysis performed for Oliverian Dam. The dam is owned, operated and maintained by the New Hampshire Department of Environmental Services, Water Division. The dam is located in the Town of Benton, New Hampshire. Included in the report is a description of pertinent features of the dam, procedures used for the analysis, assumed dam-breach conditions, and the resulting effect on downstream flooded areas, particularly the Town of Benton and Haverhill. See Plate 1, for photographs of this dam. This study was not performed because of any known likelihood of a dam-breach at this dam. The purpose is to provide information for emergency planning use.

The dam-breach flood analysis was conducted at the request of the State of New Hampshire, under the authority of the Corps of Engineers Section 206 Flood Plain Management Services (FPMS) program. This report presents the findings of a dam-breach analysis performed assuming a sunny-day and storm-day failure of the Oliverian Dam.

2. MODEL DESCRIPTION

A dam-breach analysis for Oliverian Dam was conducted using Boss Corporation's 1992 release of the National Weather Service Dam-Breach Flood Forecasting Computer Model developed by D.L. Fread. Input for the model consists of storage characteristics of the reservoir, selected geometry and duration of breach development, selected geometry of the Oliverian Brook's valley and hydraulic roughness coefficients for the downstream channel. Detailed descriptions of this data are discussed later in this report. Based on input data, the model computes the breach outflow hydrograph and routes it downstream. The analysis provides output on the attenuation of the flood hydrograph, and timing of the flood wave as it progresses downstream. These results are also discussed in detail.

3. DESCRIPTION

a. General. Oliverian Dam is located in the central western part of New Hampshire in the Town of Benton. The dam is built on the headwaters of Oliverian Brook. Oliverian Brook flows westerly for approximately 8.5 miles into the Connecticut River in the Town of Haverhill, New Hampshire.

Oliverian Dam impounds a small volume of water for recreation use. This impoundment is called the Oliverian Pond. The dam is a man-made facility whose primary purpose is to provide temporary storage of floodwaters to prevent flooding of primarily agricultural lands located below the dam. The drainage area is 11.6 square miles. The watershed is almost entirely forested. The terrain is characterized by moderately steep to very steep slopes.

The study extended from the Oliverian Dam downstream along the Oliverian Brook through the Towns of Benton and Haverhill and terminated in the Connecticut River at mile marker (MM) 8.59. The study reach included approximately eight miles of the Oliverian Brook. The study analyzed a dam failure of the Oliverian Dam. The drainage area contributing to the study reach increases from 11.6 square miles at the Oliverian Dam to 30.3 square miles at the breached dam (MM 5.17) on Oliverian Brook in the Village of Pike to 41.5 square miles immediately downstream of State Route 10/25 (MM 8.33). The study area reach is shown on Plate 2.

b. Oliverian Dam. Oliverian Dam is located on Oliverian Brook in the Town of Benton, New Hampshire. The location of Oliverian Dam is shown on Plate 2. The total drainage area of Oliverian Dam is 11.6 square miles.

Oliverian Dam is a zoned earthfill dam located in a broad, steep sided valley. It is a flood control structure with a two-stage principal spillway and an emergency spillway. Both spillways have uncontrolled inlets. The principal spillway consists of a drop inlet concrete riser which discharges to a 48-inch reinforced concrete conduit which passes through the dam. The concrete conduit discharges into a plunge pool at the pipe outlet. The emergency spillway is a 300 foot wide, ungated, grass lined earth channel. A pond drain inlet is located upstream of the principal spillway. Flow from the pond drain inlet to the drop inlet riser is controlled by a slide gate at the inlet structure.

TABLE 1

Pertinent Data
Oliverian Dam

a. Drainage Area. Oliverian Dam controls a drainage area of approximately 11.6 square miles consisting of moderately steep to very steep sloping terrain.

b. Elevations (feet NGVD)

(1) Top of dam	886.5
(2) Emergency spillway crest	874.0
(3) Principal spillway crest	849.0
(4) Stream bed at centerline of dam	835.0
(5) Normal water surface	849.0
(6) Upstream invert of principal spillway concrete conduit	836.0

c. Reservoir Surface Area (acres)

(1) Normal water surface	30
(2) Emergency spillway crest	106
(3) Pool elevation 881.0	140

d. Dam

(1) Type – Zoned earthfill dam
(2) Length - +/- 1,060 feet
(3) Height - +/- 52 feet above streambed
(4) Top width – 16 feet
(5) Side Slopes
- 2 ½ horizontal to 1 vertical at both the upstream and downstream embankments. The upstream slope has a 10 foot berm at and a 3:1 slope below elevation 849.0 feet

(6) Zoning – The core consists of unified classification SM material with a top width of 16 feet and 2 to 1 side slopes. The shells are composed of unified classification GM-GW material, approximately 2 feet thick.
(7) Impervious Core – Unified classification SM material
(8) Cutoff – Key trench with 12-foot bottom width backfilled with SM Material, depth varies from 0 to 10 feet.
(9) Grout curtain – Not applicable

e. Spillway

(1) Type –

1) Principal spillway- uncontrolled, two-stage, drop inlet concrete riser discharging to a 48-inch diameter reinforced concrete conduit.

2) Emergency Spillway – uncontrolled, earth-lined saddle spillway.

f. Regulating Outlets

Invert Elevation – 836.5 NGVD

Size - 30-inch diameter

Description – A 30-inch diameter concrete conduit extends approximately 50 feet from the riser out into the reservoir. The pond drain outlet is controlled by a slide gate at the principal spillway riser.

Control Mechanism – Pond drain outlet manually operated by lifting screw accessible from the top of the concrete riser. Principal spillway is uncontrolled.

c. Downstream Valley. The average slope of the Oliverian Book from the Oliverian Dam to the Connecticut River is 51 feet per mile. There are several small flow structures and road crossings across the Oliverian Brook between Oliverian Dam and the Connecticut River.

All the cross sectional information describing the downstream Oliverian Brook valley from MM 0.00 to MM 8.59 was obtained from field survey.

4. METHOD OF ANALYSIS

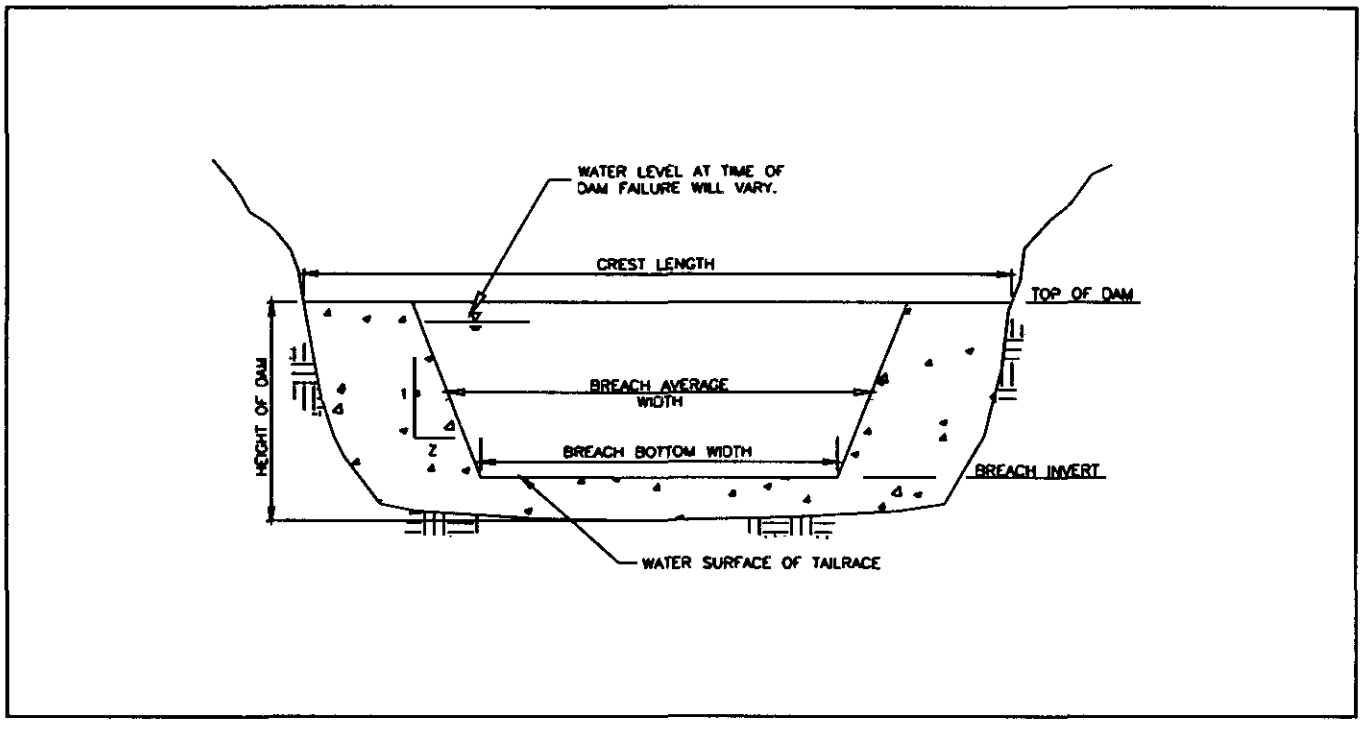
a. General. This section discusses the methods and assumptions used in the dam-breach analysis. The magnitude of a flood resulting from a hypothetical dam-breach depends not only on the size of the dam but also on the conditions of failure including the initial water level in the reservoir, size of the breach, rate of breach formation, as well as hydraulic features and initial flows in the downstream river channel. Two types of hypothetical dam failures were evaluated in this study, a sunny-day failure and a storm-day failure.

A **sunny-day** failure refers to a failure under normal water level conditions usually associated with fair weather or non-flood conditions. It often results from piping, which is the progressive internal erosion of a soil mass such as an embankment, foundation or abutment of a dam from uncontrolled seepage carrying soil particles to an unprotected exit that over time creates an erosion cavity or pipe. Once this happens, a rapid failure of the dam can occur which releases the contents of the reservoir and forms the breach discharge. Piping is the most common cause of sunny-day failures of earth dams and other dams that are constructed on earth foundations or abutments. A sunny-day failure can also result from other causes, such as a sudden failure of a conduit under pressure or a structural component of the dam.

A **storm-day** failure is associated with major storm events and floods. During periods of significant rainfall and resulting runoff, the reservoir will rise to high levels. If the storm is severe enough, and the inflow exceeds the hydraulic capacity of the spillway and reservoir storage capacity, overtopping of the embankment can occur. As flood waters flow over the dam, the erosion of the earth embankment or abutments can occur resulting in a failure of the dam and the formation of the breach discharge as the contents of the reservoir are released. Other dam failure modes such as piping, sudden structural failure or progressive failure of stone or masonry elements can be a result of high reservoir levels associated with the storm-day type failures.

The State of New Hampshire has adopted a storm-day failure criteria that simulates the flood of record in the watershed where the dam is located. There is no available data on the flood of record at Oliverian Dam. For this storm-day failure analysis it was assumed that Oliverian Dam would be discharging a 100-year flow of 350 cfs and the pool level at the dam would be at the emergency spillway crest elevation 874.0. This data was obtained from the Natural Resources Conservation Services (NRCS), the dam designer. The discharge from the dam together with the appropriate discharges from downstream uncontrolled drainage areas is used as the initial flow prior to dam failure.

b. Assumed Breach Parameters. The discharge hydrograph of a breach is a function of the inflow hydrograph and breach parameters (time of breach formation, size, and shape of breach) of a hypothetical dam failure. The breach parameters are based on the Federal Energy Regulatory Commission (FERC) guidelines. The following sketch illustrates the various dam breach parameters for a typical earthen or concrete-gravity dam. Total outflow is a combination of flows through the breach and spillway. As the breach develops, so does the breach discharge. See Table 1 for the breach parameters.



Definition Sketch of Breach Parameters

c. Assumed Pre-breach Flows. Assumed pre-breach flows on the Oliverian Brook for the dam failure simulation were developed for the downstream watershed. These are the assumed flows for the antecedent conditions that would be expected to occur with or without a dam failure.

- For the **Sunny-day** failure scenario it was assumed the antecedent conditions at the Oliverian Dam and downstream along the Oliverian Brook were approximately equal to the annual mean flow for the contributing drainage area or 1.5 cfs per square mile of drainage area.

- For the **Storm-day** failure it was assumed that the antecedent conditions at the Oliverian Dam were equal to the 100-Year peak discharge of 350 cfs as documented in the Phase I - Inspection Report.

- Based on the hydrologic conditions of the downstream watershed, lateral inflows, representing contributing flow from downstream tributaries and local runoff areas, were included at river miles MM 4.89 and MM 6.89 for the sunny-day and storm-day failure scenarios. The contributing net drainage areas at river miles MM 4.89 and MM 6.89 were 18.7 and 11.2 square miles respectively. The sunny-day lateral inflows were assumed equal to 1.5 cfs per square mile for the contributing drainage area. The storm-day lateral inflows were assumed equal to 200 cfs per square mile for the contributing drainage area.

TABLE 2
Assumed Dam Breach Parameters

Sunny-day Failure Conditions	
Oliverian Dam	
Initial pool level at start of computations	El. 850.0 NGVD
Pool level at dam failure	El. 850.0 NGVD
Breach invert elevation	El. 835.0 NGVD
Breach bottom width	130.0 feet with side slopes 0.5H : 1.0V
Time to complete formation of breach	0.50 hours
Downstream reach roughness coefficients	0.04 to 0.08
Assumed pre-breach flows	20 cfs
Assumed downstream lateral inflows	At MM 4.89 – 30 cfs At MM 6.89 – 20 cfs

Storm-day Failure Conditions	
Oliverian Dam	
Initial pool level at start of computations	El. 874.0 NGVD
Pool level at dam failure	El. 874.0 NGVD
Breach invert elevation	El. 835.0 NGVD
Breach bottom width	130 feet with side slopes 0.5H : 1.0V
Time to complete formation of breach	0.50 hours
Downstream reach roughness coefficients	0.04 to 0.10
Assumed pre-breach flows	350 cfs
Assumed downstream lateral inflows	At MM 4.89 – 3500 cfs At MM 6.89 – 2000 cfs

d. Downstream Channel Routing. A downstream channel routing analysis allows the breach discharge hydrograph to be characterized at points of interest below the dam. The downstream channel stationing is in river miles below Oliverian Dam, with river mile 0.00 at the dam. A breach hydrograph is attenuated and stored through the downstream channel and flood plain. The degree to which this breach discharge is attenuated is a function of the downstream valley storage capacity and valley roughness characteristics.

The dynamic wave method of channel routing is used in the NWS DAMBRK computer program to route the flood wave downstream. This is a hydraulic routing method that solves the complete unsteady flow equations through a given reach. Results of this method indicate attenuation of the flood wave, resulting flood stages, and the time it takes the wave to reach a section of the river.

Downstream valley data were determined by obtaining cross sections from field survey. Manning's "n" values were assigned to the channel and overbanks on the basis of the HEC-2 analysis from the Flood Insurance Study and field observations. Discharge and stage hydrographs are shown on Plates 11 and 13, for six downstream stations, MM 0.00, MM 0.65, MM 1.92, MM 3.20, MM 5.17

and MM 8.59. The locations of twenty-two cross sections are shown on Plate 2. These twenty-two were used to characterize the movement and attenuation of the dam-breach flood wave as it progresses downstream.

The geometry input to define the downstream channel does not include detailed bridge information. This study does not attempt to determine if any downstream structures will or will not fail during a dam-breach at the Oliverian Dam.

5. RESULTS OF ANALYSIS

a. General. This section discusses results of the dam failure analysis of the Oliverian Dam for the sunny-day and storm-day failures.

b. Breach Discharge Hydrograph. The peak breach discharges from the Oliverian Dam for the sunny-day and storm-day dam failures are listed below:

Dam	Peak Breach Discharges (CFS)	
	Sunny-day Failure	Storm-day Failure
Oliverian Dam	6,300	56,000

Tables 3 and 4 summarize the dam peak discharges and the downstream channel routing results under a sunny-day and storm-day failure, respectively.

Plates 3 - 6 show the pre-breach and dam-breach flood profiles for the Sunny-day dam failures. Plates 7-10 show the pre-breach and dam-breach flood profiles for the Storm-day dam failures. Plates 11 and 13 shows the breach discharge and stage hydrographs for selected cross sections throughout the reach. Plates 12 and 14 shows how the breach flood peak discharge varies with distance downstream.

TABLE 3

Oliverian Dam Failure
Downstream Channel Routing Results

Sunny-day Failure

Downstream Location (River Miles)	Peak Discharge (CFS)[1]	Peak Elevation (ft NGVD)	Time to Peak Elevation (hours)[2]	Prebreach Flow (CFS)	Prebreach Flow Elevation (ft NGVD)	Increase in Depth of Flow (feet)
Oliverian Dam MM 0.00	6300	850.0	0.3	20	850.0	0.0
St. Rt. 25 MM 0.65	1820	829.2	1.6	20	820.8	8.4
Narrows MM 1.92	710	795.0	3.9	20	791.0	4.0
MM 2.95	650	781.3	5.4	20	777.4	3.9
East Haverhill MM 3.20	650	768.6	5.6	20	765.1	3.5
MM 3.47	650	756.9	5.6	20	753.7	3.2
Jeffers Hill Road MM 4.54	640	738.4	6.1	20	733.7	4.7
Pike MM 5.21	670	724.5	6.3	50	722.3	2.2
St. Rt. 25 MM 6.08	660	654.3	6.5	50	652.4	1.9
Daniels Road MM 6.89	660	587.4	6.5	50	584.9	2.5
St. Rt. 10/25 MM 8.33	680	468.2	6.8	70	466.5	1.7

[1] Includes prebreach flows and inflow from downstream watersheds
[2] Time to peak measured from start of breach at Oliverian Dam

TABLE 4

Oliverian Dam Failure
Downstream Channel Routing Results

Storm-day Failure

Downstream Location (River Miles)	Peak Discharge (CFS)[1]	Peak Elevation (ft NGVD)	Time to Peak Elevation (hours)[2]	Prebreach Flow (CFS)	Prebreach Flow Elevation (ft NGVD)	Increase in Depth of Flow (feet)
Oliverian Dam MM 0.00	56000	874.0	0.5	350	874.0	0.0
St. Rt. 25 MM 0.65	37300	838.9	0.8	350	824.3	14.6
Narrows MM 1.92	10200	803.6	2.4	350	792.9	10.7
MM 2.95	8180	789.9	3.3	350	780.0	9.9
East Haverhill MM 3.20	8110	777.7	3.4	350	767.7	10.0
MM 3.47	8090	765.3	3.5	350	755.9	9.4
Jeffers Hill Road MM 4.54	4900	755.6	5.2	350	745.8	9.8
Pike MM 5.21	8310	739.4	5.2	3850	734.3	5.1
St. Rt. 25 MM 6.08	8300	662.2	5.3	3850	658.1	4.1
Daniels Road MM 6.89	8300	600.6	5.5	3850	597.3	3.3
St. Rt. 10/25 MM 8.33	10300	476.4	5.8	5850	473.8	2.6

[1]Includes prebreach flows and inflow from downstream watersheds
[2] Time to peak measured from start of breach at Oliverian Dam

6. DOWNSTREAM CHANNEL ROUTING

Plates 3 to 6 and Plates 7 to 10, show peak water surface profiles resulting from the pre-breach initial flow and failure flow of both the sunny-day and storm-day failure conditions, respectively. The peak dam-breach discharge computed by the DAMBRK computer program for the sunny-day and storm-day failures are included in Table 3 and 4. The maximum peak discharges for the sunny-day and storm-day failures occurs at the dam and are 6,300 cfs and 56,000 cfs respectively.

The dambreak analysis was conducted in one reach from Oliverian Dam at MM 0.00 to the Connecticut River in the Town of Haverhill, New Hampshire at MM 8.59, a distance of 8.59 miles.

a. Sunny-Day Results

Table 3 indicates the results of the dam failure analysis at various locations along the Oliverian Brook. The peak breach discharge attenuates from 6,300 cfs at Oliverian Dam to 710 cfs within the first two miles along Oliverian Brook. This reduction in the dam breach flood wave, a reduction of approximately 90%, is due to the small initial volume of water impounded by the dam at the beginning of the sunny-day analysis and the downstream valley characteristics of Oliverian Brook.

The peak discharge at State Route 25 at MM 0.65 is 1820 cfs resulting in a peak water surface elevation of 829.2. This peak does not inundate the road. The depths of inundation as a result of the dam break flood wave from MM 0.00 to MM 0.65 ranges from 10 to 14 feet.

The depth of inundation from MM 1.37 to MM 5.17 ranges from 4 to 8 feet. The peak discharge ranges from 670 to 710 cfs within this reach of the Oliverian Brook.

The depth of inundation from MM 5.21 to MM 8.59 ranges from 3 to 4 feet with a peak discharge range from 670 to 680 cfs.

b. Storm-Day Results

Table 4 indicates the results of the dam failure analysis at various locations along the Oliverian Brook. The peak breach discharge attenuates from 56,000 cfs at Oliverian Dam, MM 0.00 to 4,900 cfs at MM 4.54. This reduction of approximately 90 % in the dam breach flood wave, is due to the valley characteristics of Oliverian Brook. The upper reach of Oliverian Brook, from the dam at MM 0.00 to MM 5.21, has a wide flood plain and a gradual valley slope of 21 feet per mile. This type of valley characteristic is conducive to flood wave attenuation. The lower reach of the Oliverian Brook, from MM 5.21 to MM 8.59, is a narrow valley with a steep valley slope of 97 ft per mile. Minimal attenuation and high velocities characterize a narrow, steep river valley.

The peak discharge at State Route 25 at MM 0.65 is 37,300 cfs, resulting in a peak water surface elevation of 838.9 feet. This peak water surface elevation will inundate the road by 8 to 9 feet. The depths of inundation as a result of the dam break flood wave from MM 0.00 to MM 0.65 ranges from 20 to 26 feet.

The depth of inundation from MM 1.37 to MM 3.47 ranges from 12 to 14 feet. The peak discharge ranges from 8100 to 11600 cfs within this reach of the Oliverian Brook.

The depth of inundation from MM 4.54 to MM 5.30 ranges from 15 to 25 feet with a peak discharge range from 4900 to 8300 cfs.

The depth of inundation from MM 5.99 to MM 8.59 ranges from 8 to 12 feet with a peak discharge range from 8300 to 10300 cfs.

The peak water surface profiles on Plates 7 to 10 show that the bridges crossing over the Oliverian Brook at MM 0.65, MM 2.95, MM 3.47, MM 4.54, and MM 6.89 are overtopped during the storm-day dam failure.

The increase in the dam-breach flood over the assumed prebreach flood levels is an indication of the flooding that can be expected as a result of a dam-breach. It is again noted that the assumed pre-breach flood conditions for the storm-day event are rare conditions, and there would be flooding prior to failure. These pre-breach high flows are due to uncontrolled spillway discharges at the dam along with downstream lateral inflows and are not attributable to a dam failure.

7. INUNDATION MAPPING

The limits of inundation were computed by routing the breach discharge hydrograph through the downstream valley cross sections and delineating the resulting maximum stages on the base map. Mapping will be done by the Department of Environmental services, and will be included in the Emergency Action plan prepared by them. The base map used is based on a 20-foot contour interval 1:24,000 scale USGS quadrangle. Locations of the twenty selected downstream stations are graphically illustrated on Plate 2. Although any structures shown within these limits were assumed to be inundated, certain structures may be excluded as a result of local conditions and elevations.

8. DISCUSSION

The dam-breach analysis for Oliverian Dam was based on engineering application of certain laws of physics, considering the physical characteristics of the project and downstream channel and conditions of failure. Due to the highly unpredictable nature of a dam-breach and the ensuing sequence of events, the results of this study should not be viewed as exact but only as an approximate quantification of the dam-breach flood potential. For purposes of analysis, downstream conditions are assumed to remain constant, and no allowance is made for possible enlargement or relocation of the river channel due to scour or temporary damming effects, all of which could affect, to some extent, the resulting magnitude and timing of flooding.

The results of a dam failure could be damaging at areas downstream of the dam. However, for the adopted pre-breach flows for the storm-day scenario, due to uncontrolled spillway discharges and downstream inflows associated with these rare events, channel capacities would have been exceeded and flooding would have occurred prior to a dam-breach at the dam. It should be noted that a dam

failure occurring during a more frequent (less severe) event would result in a more prominent rise over pre-breach flood levels. However, the peak breach levels and flooded areas would be less than the adopted results.

Also, this study does not attempt to determine if any downstream structures will or will not fail during a dam-breach at the Oliverian Dam.

The dam-breach analysis ended on Oliverian Brook, about eight miles downstream of Oliverian Dam. The State of New Hampshire's criteria for ending dam-breach analyses is to compute the water surface elevation downstream of the dam until the breach water surface elevations are within 2.0 feet of the prebreach water surface elevations. The sunny-day failure analysis is within the State's 2.0-foot criteria however the storm-day failure water surface elevations are at 2.6 feet of the prebreach water surface elevation. Base on directions from the State of New Hampshire the storm-day failure analysis was concluded at the Connecticut River.

9. REFERENCES

U.S. Army Corps of Engineers, New England Division, Phase I Inspection Report – National Dam Inspection Program, Oliverian Dam, Benton, New Hampshire, Concord, Massachusetts, May 1974.

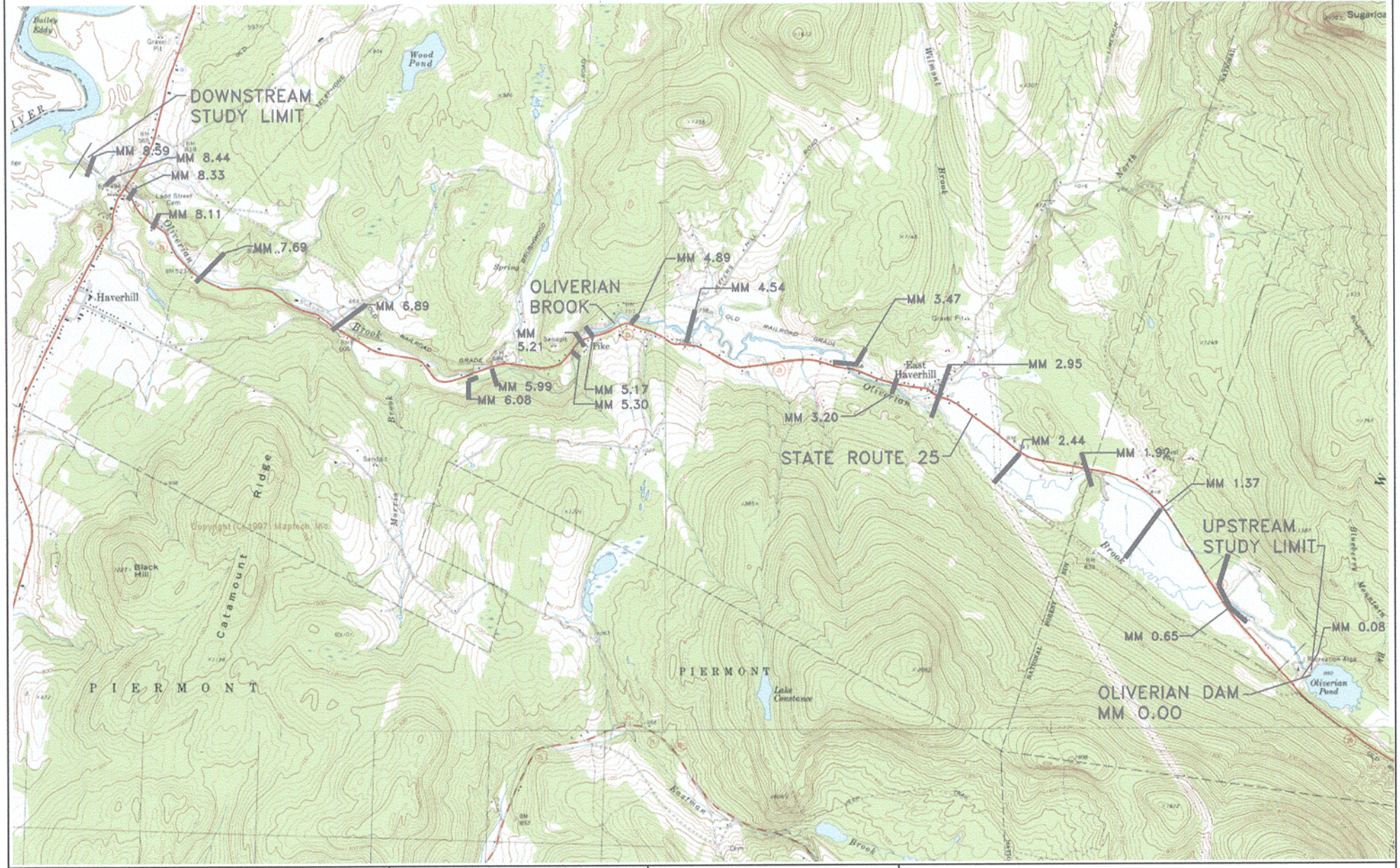
Boss Corporation, Boss DAMBRK 3.0, Madison, WI, 1992.

Fread, D.L., DAMBRK: The NWS Dam-Break Flood Forecasting Model, Office of Hydrology, National Weather Service, Silver Spring, MD, 1998.

PLATES

Oliverian Dam – Looking Upstream at Principal Spillway

Oliverian Dam – Looking at Principal Spillway Discharge Outlet Pipe



N

MAP FROM U.S.G.S.
NEWBURY, N.H., CREATED 1973
EAST HAVERHILL, N.H., CREATED 1967
QUADRANGLES

1" = 3800'±
SCALE IN FEET

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

DuBois & King inc.
engineering planning management development

OLIVERIAN DAM
TOWN OF BENTON, NEW HAMPSHIRE

DAM–BREAK FLOOD ANALYSIS

PLATE 2
CROSS–SECTION LOCATION AND SITE MAP

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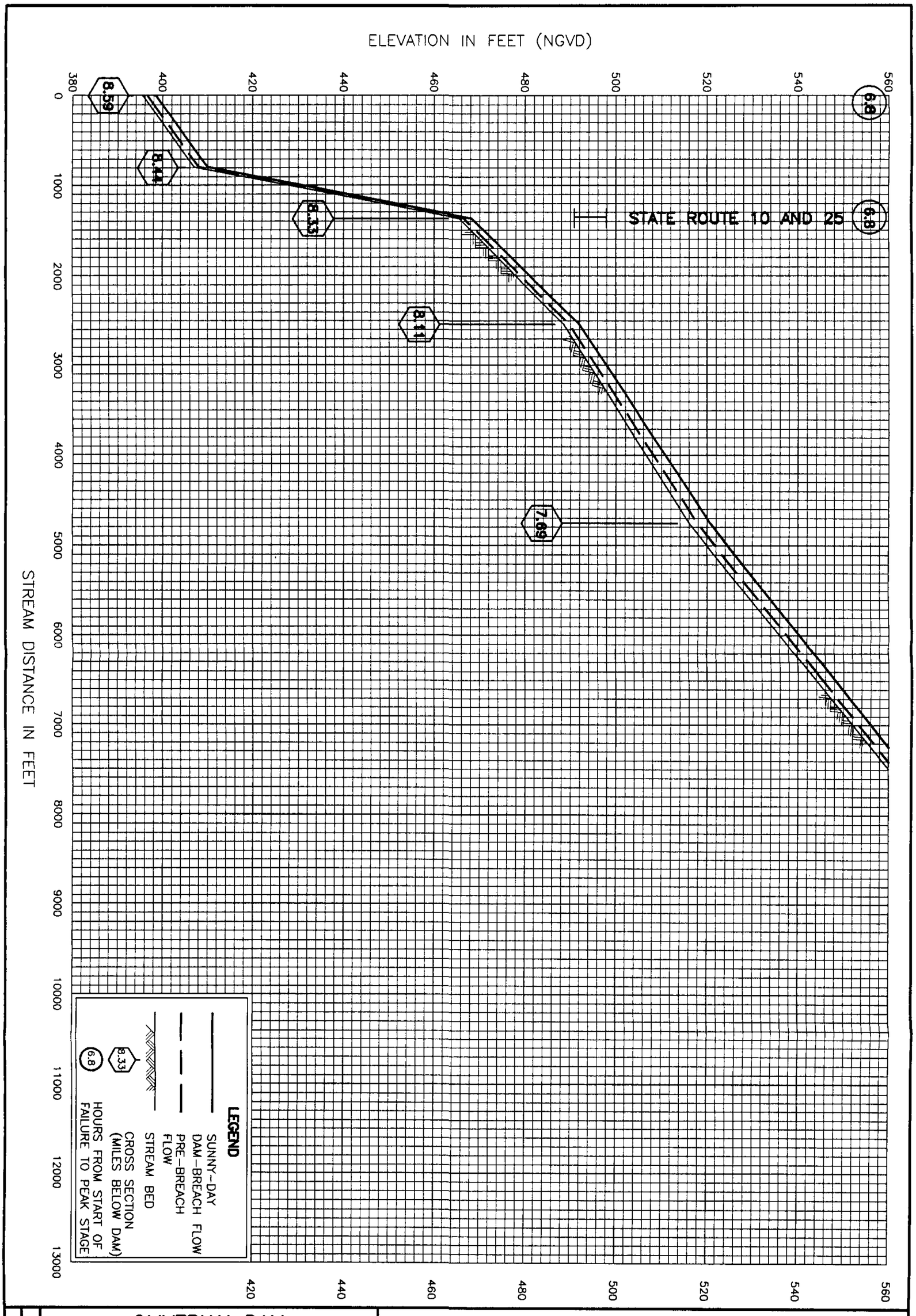

OLIVERIAN DAM
SUNNY-DAY
DAM-BREACH FLOOD ANALYSIS

FLOOD PROFILES

OLIVERIAN BROOK

PLATE NO. 3

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ELEVATION IN FEET (NGVD)

560 580 600 620 640 660 680 700 720 740

STREAM DISTANCE IN FEET

6500 7500 8500 9500 10500 11500 12500 13500 14500 15500 16500 17500 18500 19500

DANIELS ROAD

STATE ROUTE 25

UPSTREAM OF STATE ROUTE 25

BREACHED DAM

6.99 6.5 6.08 5.99 6.5 5.30 5.21 6.3 5.1

LEGEND

SUNNY-DAY

DAM-BREACH FLOW

PRE-BREACH FLOW

STREAM BED

5.21 CROSS SECTION (MILES BELOW DAM)

6.3 HOURS FROM START OF FAILURE TO PEAK STAGE

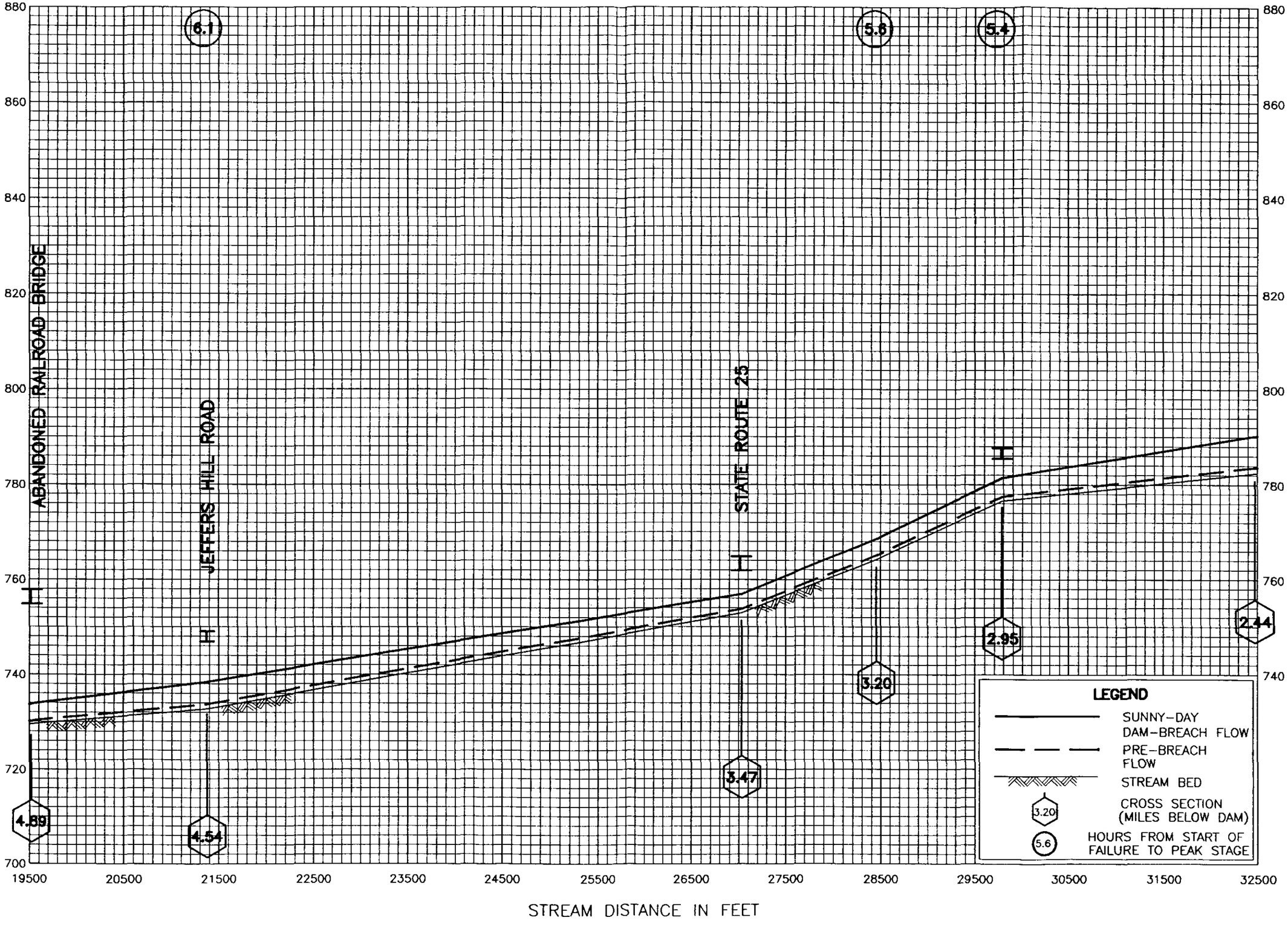
600 620 640 660 680 700 720 740

OLIVERIAN DAM
SUNNY-DAY
DAM-BREACH FLOOD ANALYSIS

FLOOD PROFILES

OLIVERIAN BROOK

PLATE NO. 4



FLOOD PROFILES

OLIVERIAN BROOK

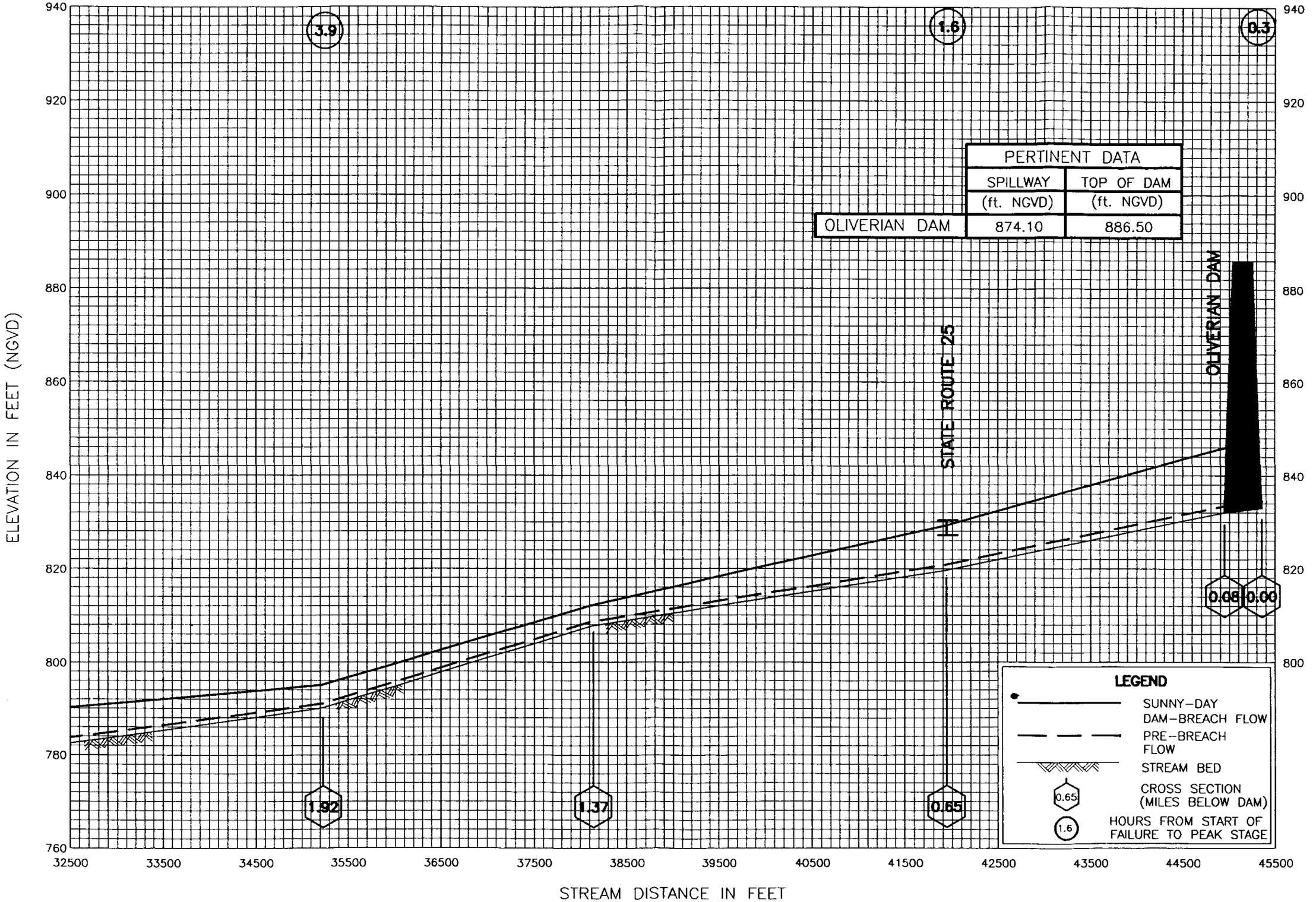
OLIVERIAN DAM
SUNNY-DAY
DAM-BREACH FLOOD ANALYSIS

PLATE NO. 5

FLOOD PROFILES

OLIVERIAN BROOK

PERTINENT DATA		
	SPILLWAY (ft. NGVD)	TOP OF DAM (ft. NGVD)
OLIVERIAN DAM	874.10	886.50



OLIVERIAN DAM
SUNNY-DAY
DAM-BREACH FLOOD ANALYSIS

PLATE NO. 6

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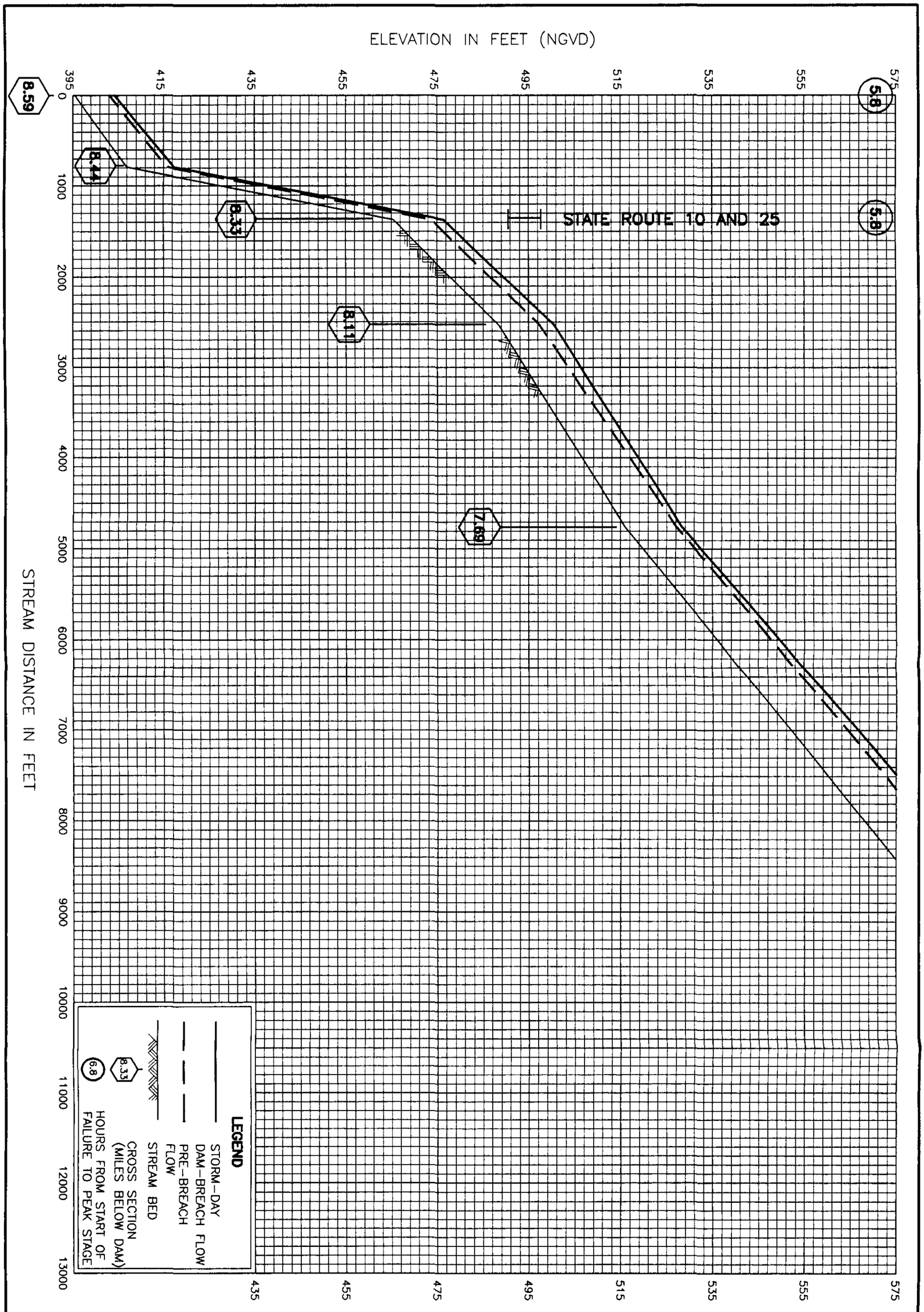


FLOOD PROFILES

OLIVERIAN BROOK

OLIVERIAN DAM
STORM-DAY
DAM-BREACH FLOOD ANALYSIS
TOWN OF DENTON, NH

PLATE NO. 7

\\leonardo\data\PROJECTS\R15707L6\dwg\Profile\olivestormy.dwg Wed Apr 05 17:24:31 2000

ELEVATION IN FEET (NGVD)

575 595 615 635 655 675 695 715 735 755

6500 7500 8500 9500 10500 11500 12500 13500 14500 15500 16500 17500 18500 19500

STREAM DISTANCE IN FEET

DANIELS ROAD

STATE ROUTE 25

UPSTREAM OF STATE ROUTE 25

BREACHED DAM

6.69 5.5 5.3 5.08 5.98 5.30 5.21 5.17 5.2

LEGEND

STORM-DAY

DAM-BREACH FLOW

PRE-BREACH FLOW

STREAM BED

5.21 CROSS SECTION (MILES BELOW DAM)

5.2 HOURS FROM START OF FAILURE TO PEAK STAGE

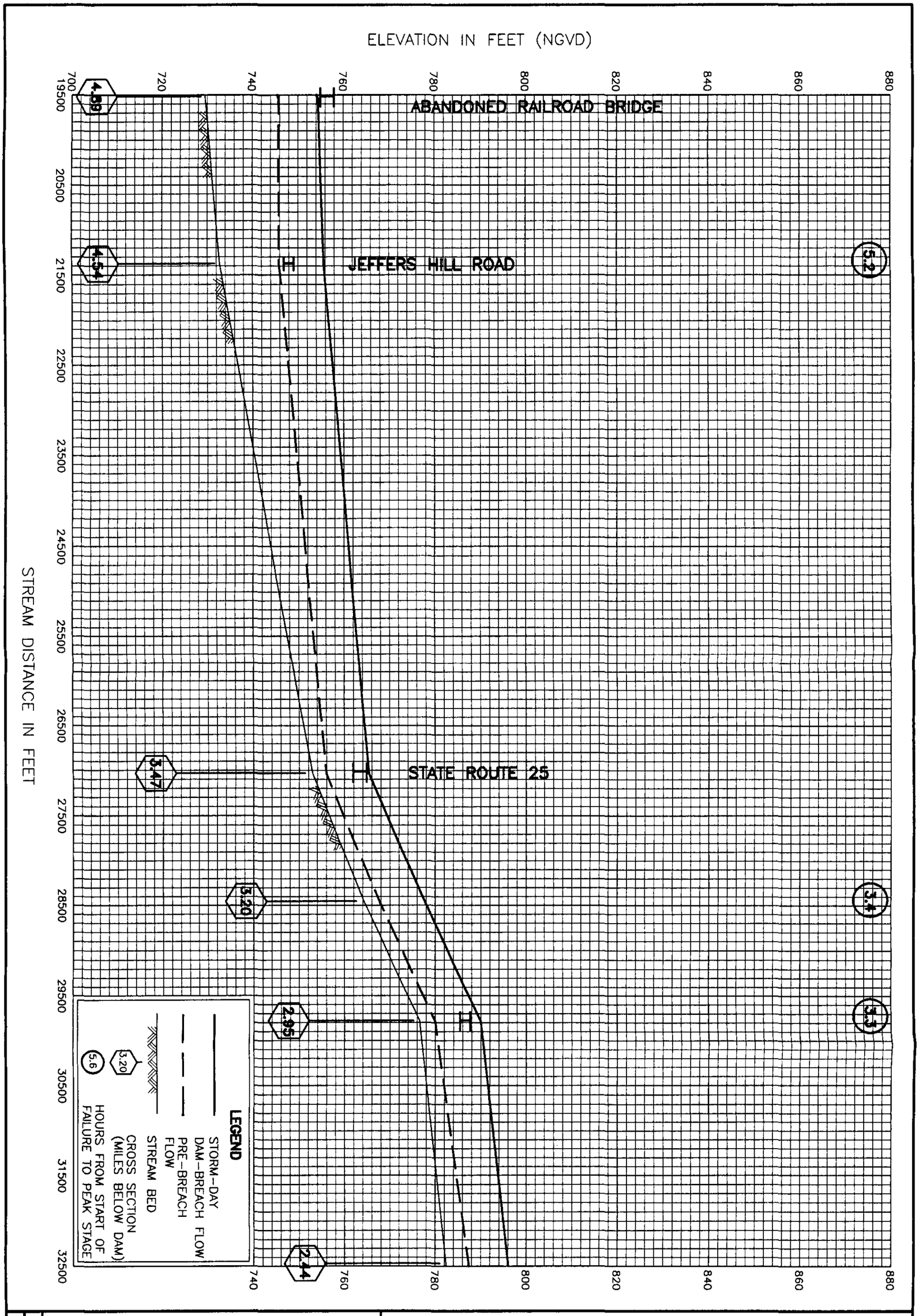
OLIVERIAN DAM
STORM-DAY
DAM-BREACH FLOOD ANALYSIS

FLOOD PROFILES

OLIVERIAN BROOK

PLATE NO. 8

\\leonardo\data\PROJECTS\A15707L6\dwg\Profile\olivestormy.dwg Wed Apr 05 17:25:02 2000

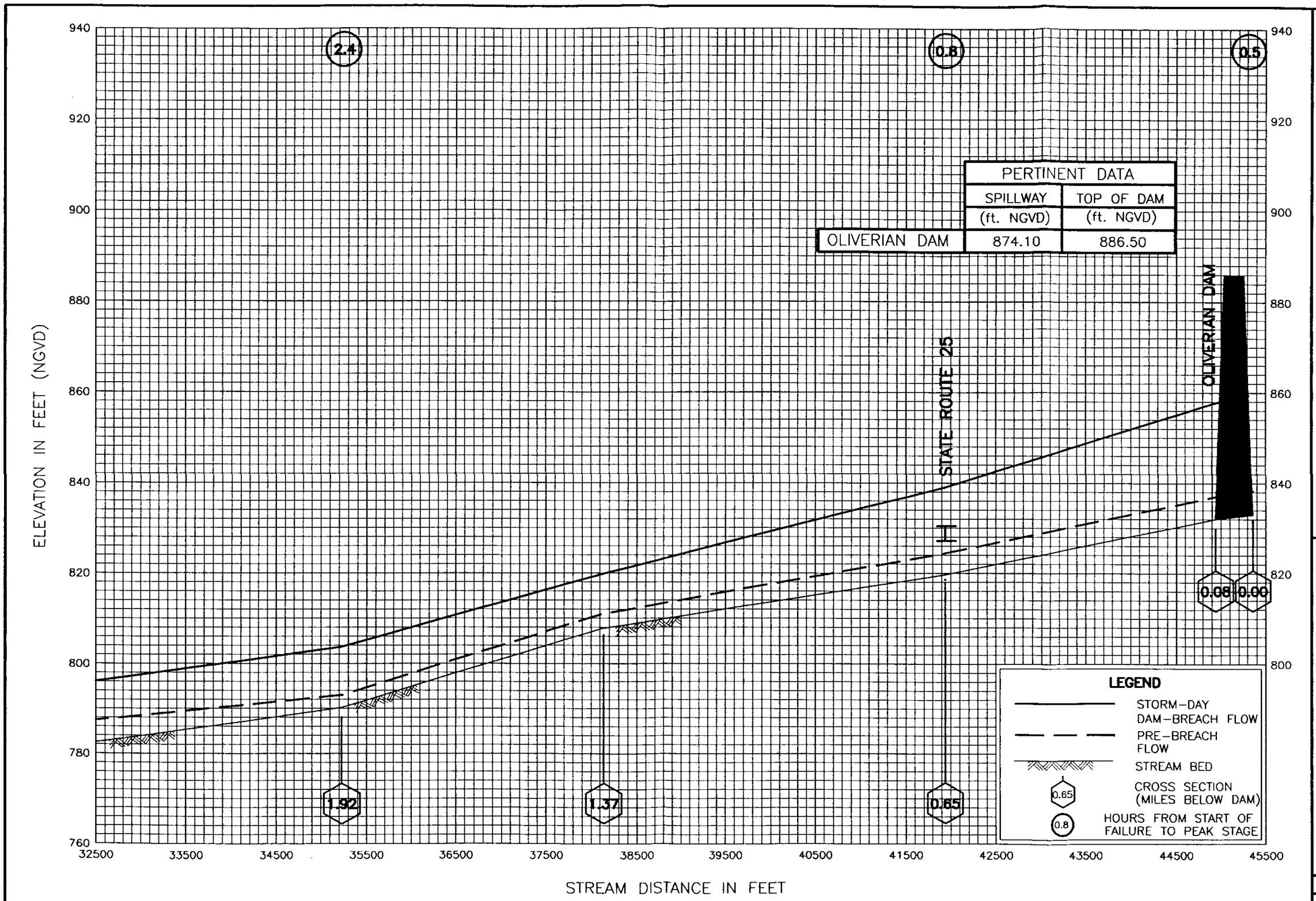


OLIVERIAN DAM
STORM-DAY
DAM-BREACH FLOOD ANALYSIS

FLOOD PROFILES

OLIVERIAN BROOK

PLATE NO. 9



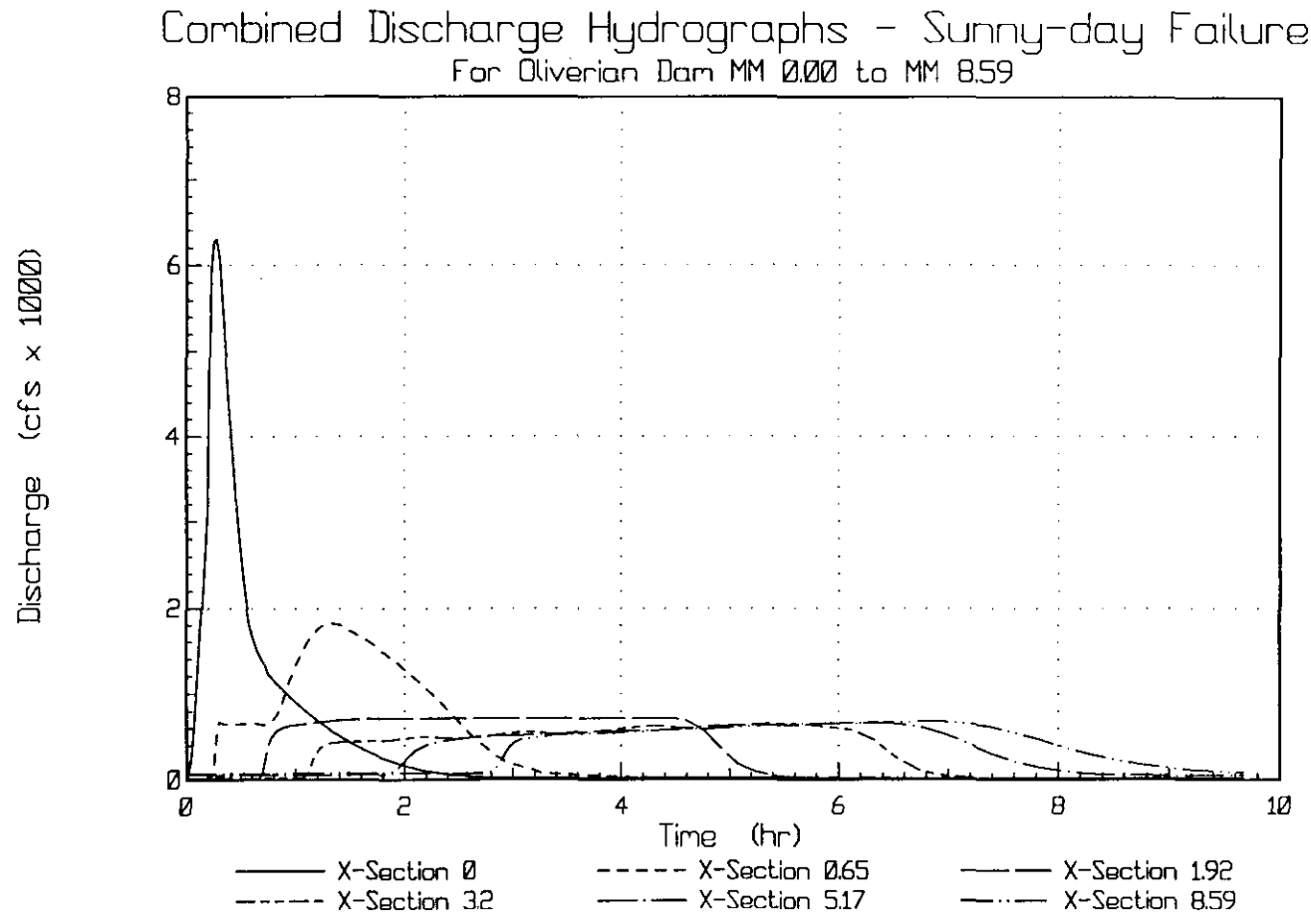
FLOOD PROFILES

OLIVERIAN BROOK

OLIVERIAN DAM
STORM-DAY
DAM-BREACH FLOOD ANALYSIS

PLATE NO. 10

\\leonardo\data\PROJECTS\R15707L6\dwg\Profile\olivestormy.dwg Wed Apr 05 17:25:30 2000


Combined Discharge Hydrographs - Sunny-day Failure
For Oliverian Dam MM 0.00 to MM 8.59
Discharge (cfs x 1000)
8
6
4
2
0
0
2
4
6
8
10
Time (hr)
X-Section 0
X-Section 0.65
X-Section 1.92
X-Section 3.2
X-Section 5.17
X-Section 8.59

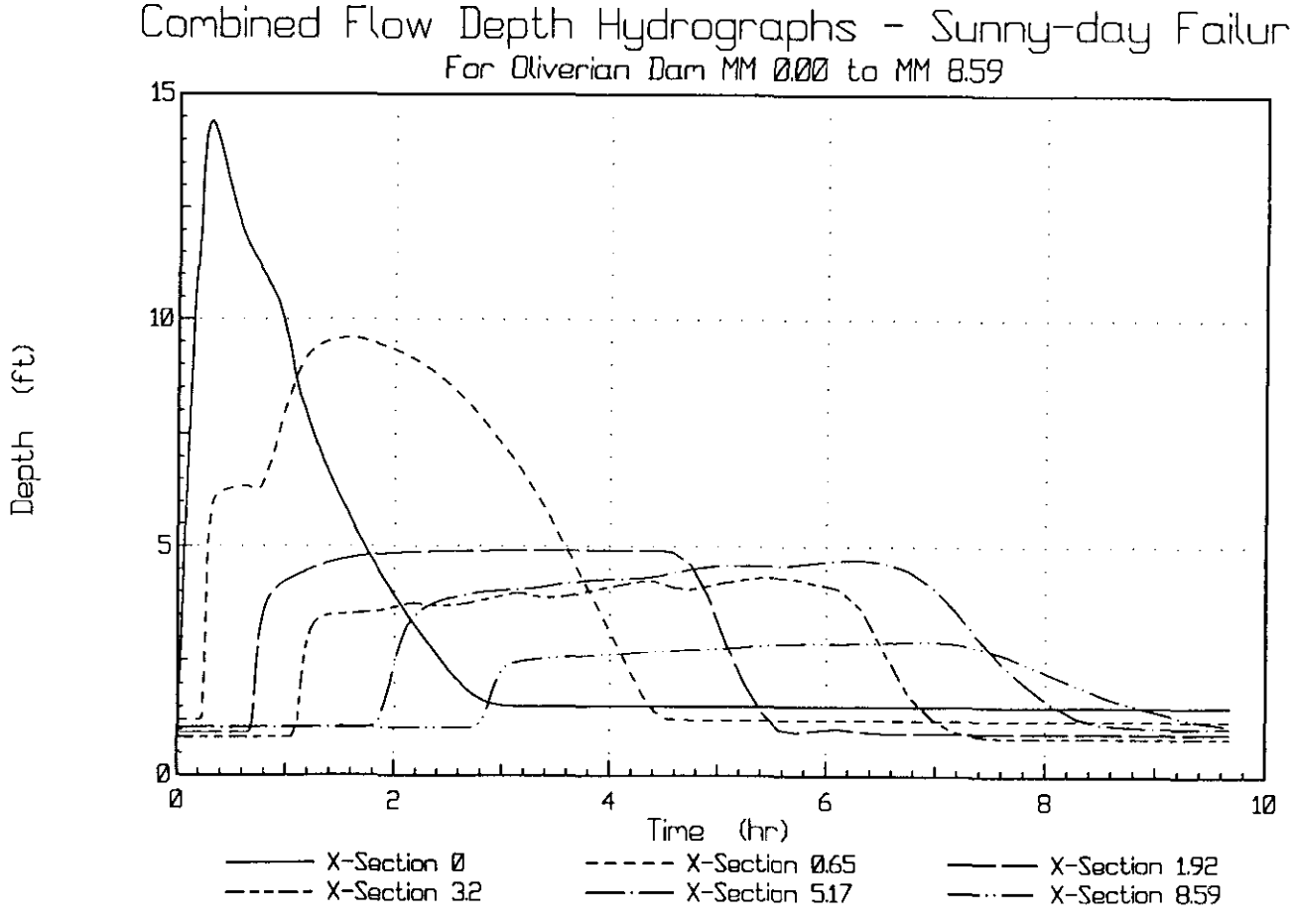

Combined Flow Depth Hydrographs - Sunny-day Failure
For Oliverian Dam MM 0.00 to MM 8.59
Depth (ft)
15
10
5
0
0
2
4
6
8
10
Time (hr)
X-Section 0
X-Section 0.65
X-Section 1.92
X-Section 3.2
X-Section 5.17
X-Section 8.59

PLATE 11

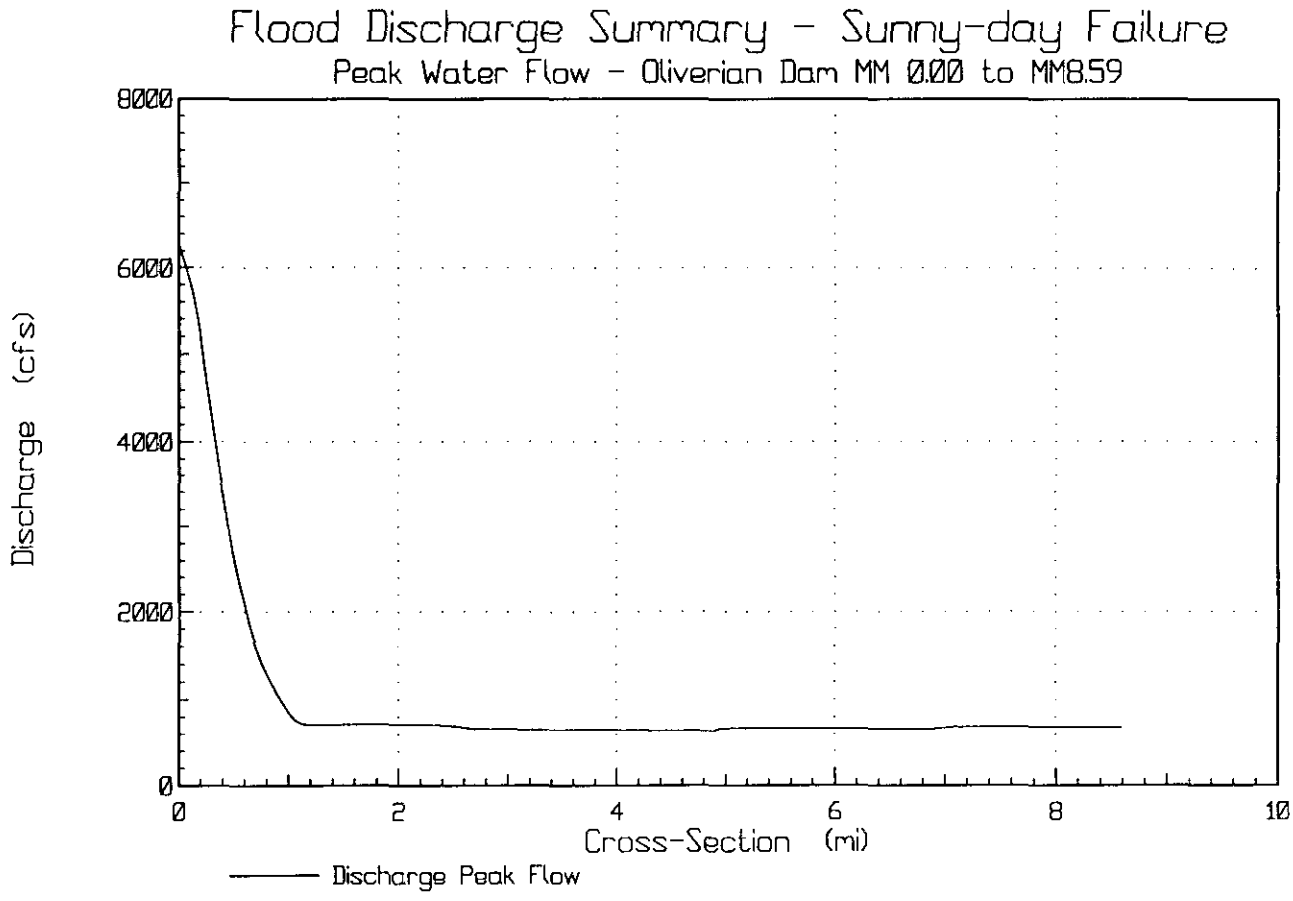
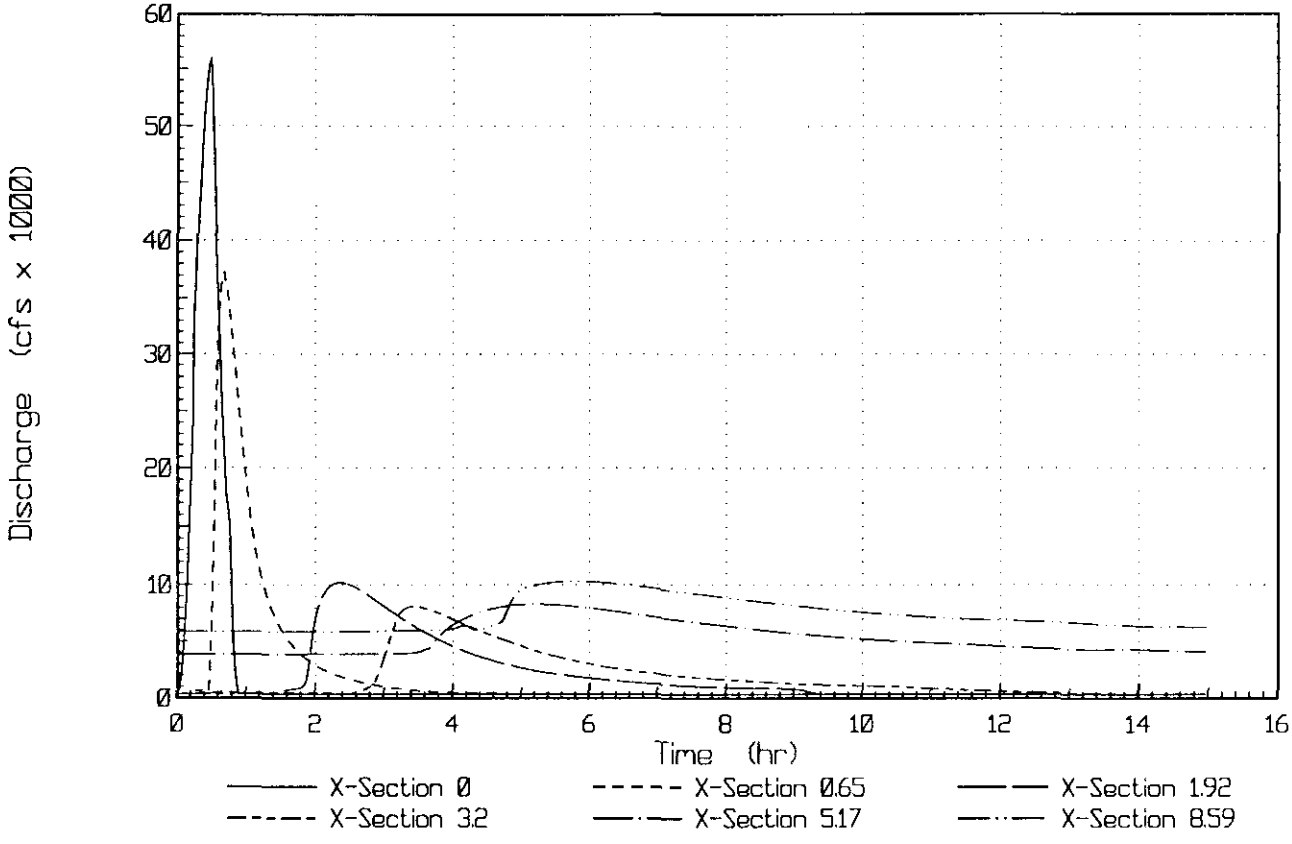

Flood Discharge Summary - Sunny-day Failure
Peak Water Flow - Oliverian Dam MM 0.00 to MM8.59
Discharge (cfs)
8000
6000
4000
2000
0
0
2
4
6
8
10
Cross-Section (mi)
Discharge Peak Flow

PLATE 12

Combined Discharge Hydrographs - Storm-day Failure

For Oliverian Dam MM 0.00 to MM 8.59



Combined Flow Depth Hydrographs - Storm-day Failure

For Oliverian Dam MM 0.00 to 8.59

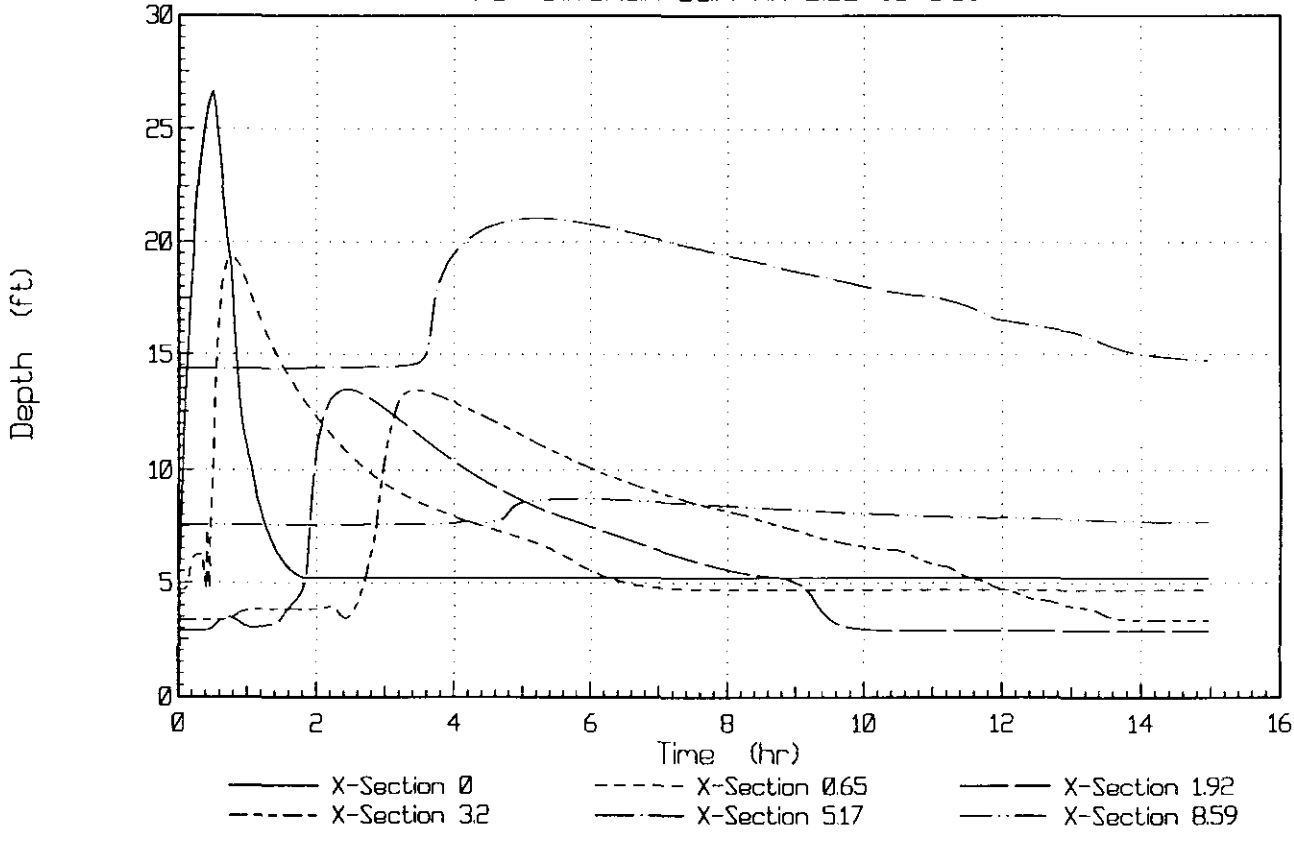


PLATE 13

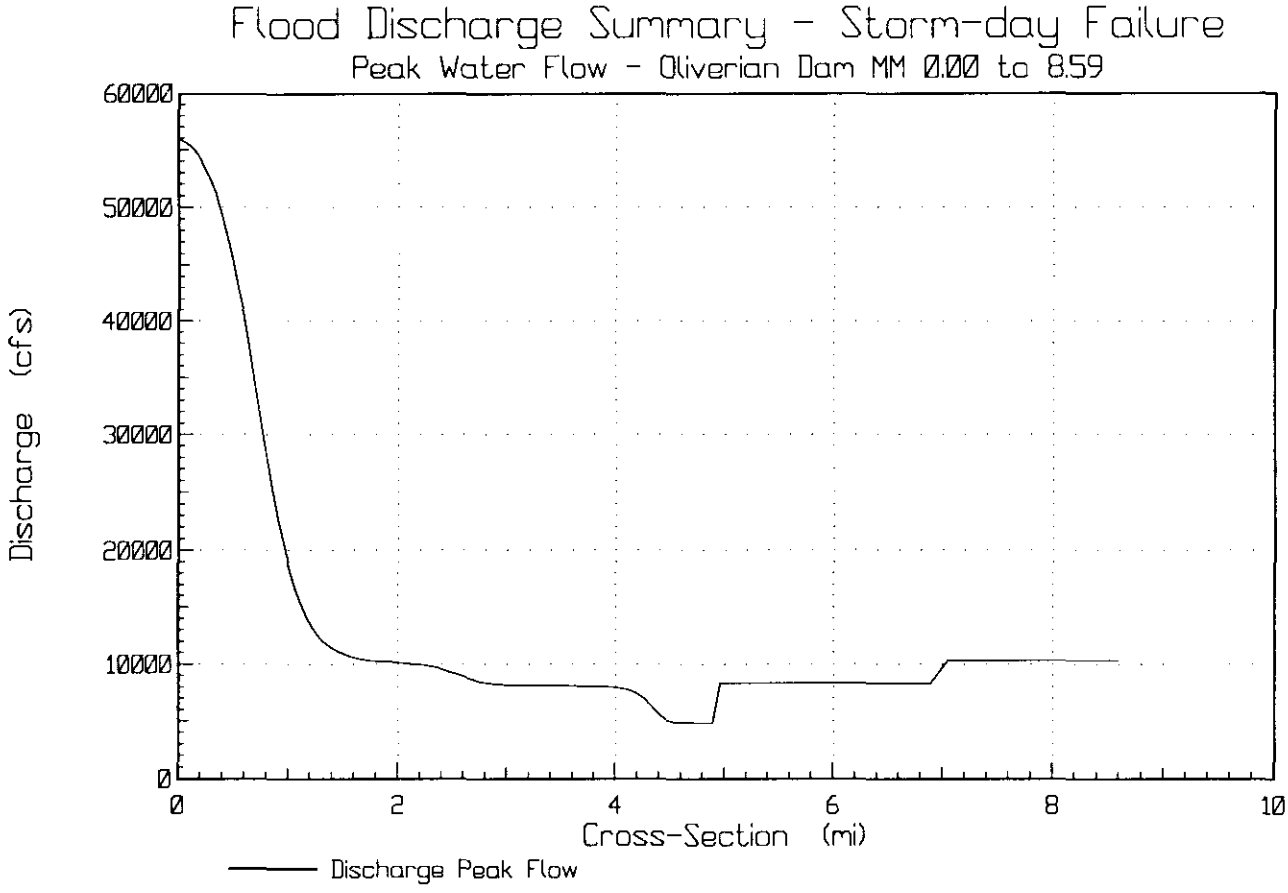

Flood Discharge Summary - Storm-day Failure
Peak Water Flow - Oliverian Dam MM 0.00 to 8.59
Discharge (cfs)
60000
50000
40000
30000
20000
10000
0
0
2
4
6
8
10
Cross-Section (mi)
Discharge Peak Flow

PLATE 14